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WASHINGTON, D.C. 20546

REPLY TO
ATTN OF: GP

TO: USI/Scientific & Technical Information Division
Attention: Miss Winnie M. Morgan

FROM: GP/Office of Assistant General Counsel for Patent Matters

SUBJECT: Announcement of NASA-Owned U. S. Patents in STAR

In accordance with the procedures agreed upon by Code GP and Code USI, the attached NASA-owned U. S. Patent is being forwarded for abstracting and announcement in NASA STAR.

The following information is provided:

U. S. Patent No. : 3,534,375

Government or Corporate Employee : California Institute of Technology Pasadena, California

Supplementary Corporate Source (if applicable) : Jet Propulsion Laboratory

NASA Patent Case No. : NPO-10539

NOTE - If this patent covers an invention made by a corporate employee of a NASA Contractor, the following is applicable:
Yes [x] No [ ]
Pursuant to Section 305(a) of the National Aeronautics and Space Act, the name of the Administrator of NASA appears on the first page of the patent; however, the name of the actual inventor (author) appears at the heading of Column No. 1 of the Specification, following the words ". . . with respect to an invention of . . ."

Elizabeth A. Carter
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Enclosure
Copy of Patent cited above

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N71-11285

Oct. 13, 1970 T. O. PAINE 3,534,375
DEPUTY ADMINISTRATOR OF THE NATIONAL AERONAUTICS
AND SPACE ADMINISTRATION
MULTI-FEED CONE CASSEGRAIN ANTENNA
Filed July 9, 1968 2 Sheets-Sheet 1

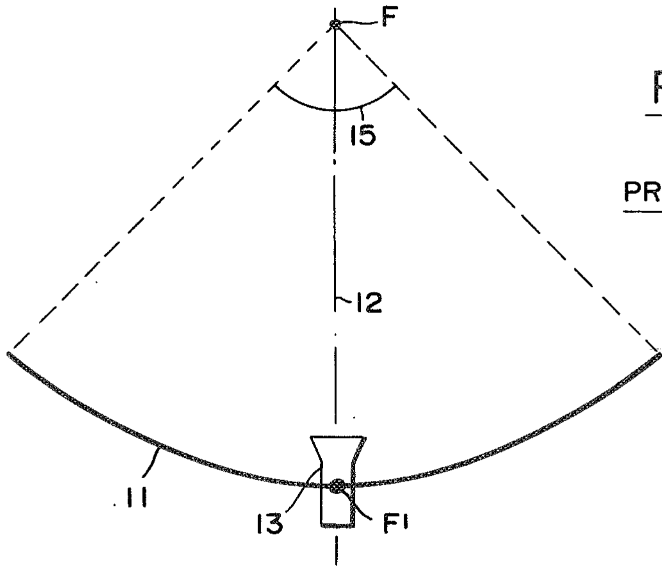

FIG. 1

PRIOR ART

FIG. 2

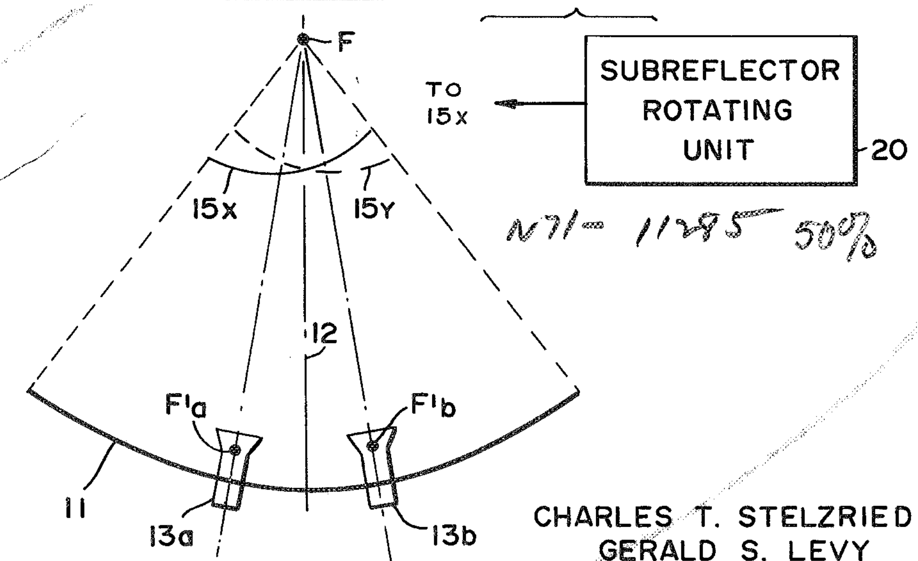

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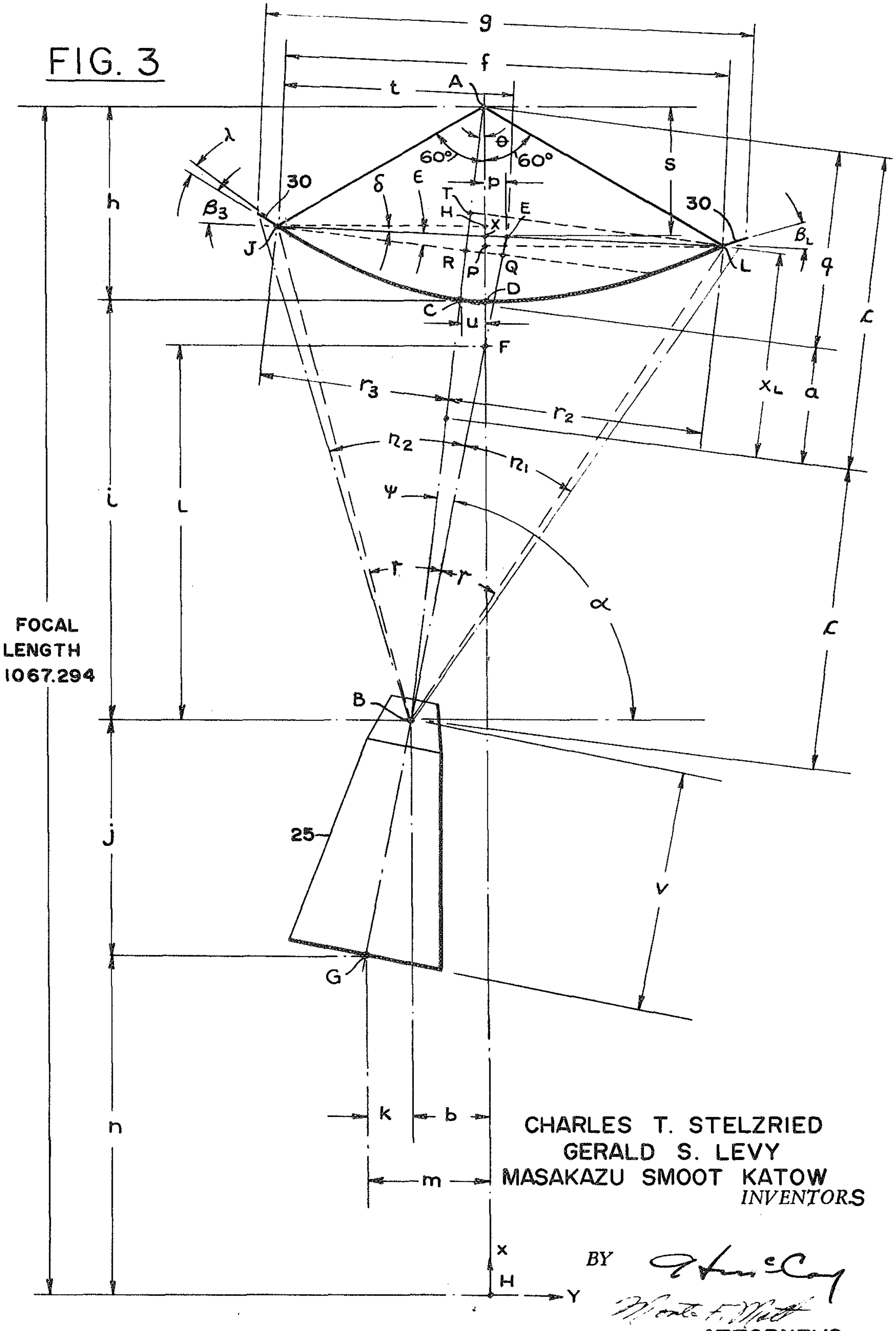
FIG. 3



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United States Patent Office

3,534,375
Patented Oct. 13, 1970

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3,534,375
MULTI-FEED CONE CASSEGRAIN ANTENNA

T. O. Paine, Deputy Administrator of the National Aeronautics and Space Administration, with respect to an invention of Charles T. Stelzried, La Crescenta, Gerald S. Levy, La Canada, and Masakazu Smoot Katow, Los Angeles, Calif.

Filed July 9, 1968, Ser. No. 743,429
Int. Cl. H01q 19/12, 19/14
U.S. Cl. 343—779 7 Claims

ABSTRACT OF THE DISCLOSURE

A Cassegrain antenna with a plurality of feeds, fixedly positioned with respect to a parabolic reflector about the antenna's axis of symmetry, is disclosed. The phase centers of all the feeds are in a plane, perpendicular to the axis of symmetry. A hyperbolic subreflector which is asymmetrically truncated is included. The subreflector is rotatable about the axis of symmetry so as to reflect signals between the parabolic reflector and a selected one of the feeds.

ORIGIN OF INVENTION

The invention described herein was made in the performance of work under a NASA contract and is subject to the provisions of Section 305 of the National Aeronautics and Space Act of 1958, Public Law 85–568 (72 stat. 435; 42 U.S.C. 2457).

BACKGROUND OF THE INVENTION

Field of the invention

This invention generally relates to antenna design and, more particularly, to a Cassegrain antenna with a plurality of feed cones.

Description of the prior art

The structure and principles of operation of a Cassegrain antenna are well known by those familiar with antenna design. All known prior art Cassegrain antennas consist of a single feed cone which is typically located at or near the vertex of a parabolic reflector. A hyperbolic subreflector, hereafter also referred to simply as the subreflector, or the hyperbola is located in front of the reflector or parabola, between its vertex and its focal point or focus.

Parallel rays coming from a target, assumed to be at infinity, are reflected by the parabola as a converging beam and are rereflected by the hyperbola converging at the position of the feed cone or feed. In essence, the hyperbolic subreflector images the feed so that it appears as a virtual image at the focal point of the parabola.

Typically, a feed cone system is designed to operate at a selected frequency in a selected frequency band. Attempts to increase the usefulness of a Cassegrain antenna, especially of the type used for space exploration, have led to the design of multi-frequency feed cones so that one cone could be used for several missions for experiments in a specified frequency band, such as the S-band.

However, from the use of such a multi-frequency feed cone, it has become clear that meaningful improved performance and the ability to perform experiments at various frequencies could only be achieved by the use of special purpose cones, each one of which is specifically designed to receive signals in a relatively narrow frequency range. However, as presently constructed, in order to change the feed system of a Cassegrain antenna from one special purpose cone to another, it is necessary to remove

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the entire Cassegrain feed support structure, an operation which requires a considerable amount of time.

A need therefore exists for an improved Cassegrain antenna in which feed cone changing is accomplishable in a minimum of time.

OBJECTS AND SUMMARY OF THE INVENTION

It is a primary object of the present invention to provide a new improved Cassegrain antenna.

Another object of the present invention is to provide a Cassegrain antenna with a multi-feed cone arrangement.

A further object of the present invention is to provide a Cassegrain antenna which is rapidly controllable to operate with any one of a plurality of feed cones.

Still a further object of the present invention is to provide a Cassegrain antenna with a relatively simple arrangement for rapidly switching the antenna to incorporate therein any one of a plurality of feed cones, supported therein.

These and other objects of the present invention are achieved by providing a Cassegrain antenna in which a plurality of feed cones, hereafter referred to generally as the multi-feed cone arrangement, are fixedly positioned with respect to the parabolic reflector. The antenna also incorporates an asymmetrically truncated hyperbolic subreflector which is rotatable about the antenna's center axis to focus on one of the feed cones which is to be used. The configuration of the hyperbolic subreflector is selected so that one of its conjugate foci coincides with the parabola's focal point, while its other focus coincides with the phase center of the particular feed cone to be used. Thus, instead of changing the feed system of the antenna by replacing one special purpose cone with another, feed cone changing is accomplished in the present invention by rotating the hyperbolic subreflector from one feed cone to the other.

The novel features of the invention are set forth with particularity in the appended claims. The invention will best be understood from the following description when read in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagram which is useful in explaining a prior art Cassegrain antenna;

FIG. 2 is a diagram which is useful in explaining the improved Cassegrain antenna of the present invention; and

FIG. 3 is an illustration of an asymmetrically truncated hyperbolic subreflector actually reduced to practice in one embodiment of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Prior to explaining the novel features of the present invention, reference is made to FIG. 1 which is a simplified diagram, useful in explaining the geometry of a conventional signal feed Cassegrain antenna. Therein, numeral **11** designates the antenna's parabolic reflector with a focal point F located on the antenna's axis of symmetry which is designated by numeral **12**. A single feed system **13** is shown located with its phase center at a point F′, which together with point F represent the conjugate foci of a hyperbolic subreflector **15**. The foci are shown aligned on the axis of symmetry **12**.

Unlike such a prior art single feed Cassegrain antenna, in accordance with the teachings of the present invention, which may best be explained in conjunction with FIG. 2, a plurality of feeds, which are fixedly supported with respect to the parabolic reflector **11**, are incorporated. In FIG. 2, only two feeds **13a** and **13b** are diagrammed. It

should, however, be appreciated that any number of feeds may be incorporated. In one specific embodiment which was actually reduced to practice, three feeds, spaced 120° apart, were incorporated. The phase centers of the two feeds **13**a and **13**b, designated in FIG. 2 by F'_a and F'_b are located equidistantly from the axis of symmetry **12**, and in a plane which is perpendicular to the axis **12**.

Unlike prior art in which the hyperbolic subreflector is fixedly positioned, in the Cassegrain antenna of the present invention a rotatable subreflector **15**x is included. The subreflector **15**x is rotatable about the axis of symmetry **12** by a subreflector rotating unit, which is designated in FIG. 2 by block **20**.

The subreflector which is hyperbolic is truncated asymmetrically, a requirement dictated by the off-axis-of-symmetry location of each of the feeds. The asymmetrically truncated hyperbolic subreflector **15**x is designed so that after the subreflector is rotated and positioned so as to focus on one of the feeds, its two foci coincide with the parabolic focal point F and the phase center of the particular feed. In the arrangement diagrammed in FIG. 2 the subreflector **15**x is shown focused on feed **13**a, while the dashed line **15**y represents the position of the subreflector, required for focusing on the second feed **13**b.

From the foregoing it should thus be apparent that switching from one feed to another does not require changing of a feed system, which as experienced in the past is very time consuming. In accordance with the present invention, switching is accomplished by rotating the asymmetrically truncated subreflector **15**x so that its real focal point coincides with the phase center of the desired feed. It should further be pointed out that the rotation is performed about the antenna's axis of symmetry **12**. In the particular diagrammed arrangement of the two feeds, if the two are located 180° apart, all that is required to switch the antenna from one feed to the other is to rotate the subreflector **15**x by 180°. Likewise, 120° rotation of the subreflector **15**x is required in the previously referred to embodiment in which three feeds, 120° apart, are incorporated.

It should be pointed out that the particular shape of the asymmetrically truncated hyperbolic subreflector depends on the overall antenna dimensions, including the size and dimensions of the parabolic reflector **11**, which defines the location of the focal point F, and the distance between the phase center of each feed and the focal point F. It should also be pointed out that any conventional means and techniques may be employed in the implementation of unit **20** (FIG. 2) to controllably rotate the subreflector **15**x about axis **12**.

For explanatory and exemplary purposes only, reference is made to FIG. 3 which is a useful illustration of the truncation of the hyperbolic subreflector **15**x, incorporated in the three-feed antenna previously referred to. In FIG. 3, the letter A designates the parabola's focal point, corresponding to the previously defined point F. Although the parabolic reflector is not shown its vertex is designated by the letter H. Numeral **25** represents one of the three feeds. The curved surface of the hyperbolic reflector is along line JCDL. Numeral **30** designates a flange about the subreflector. The function of the flange does not form part of this invention and therefore will not be discussed in any detail. The accompanying legend provides the dimensions and angles of the specific embodiment illustrated in FIG. 3.

LEGEND

Points:

- A—Focus of the paraboloid and the secondary focus of the hyperboloid
- B—Primary focus of the hyperboloid
- C—Vertex of hyperboloid
- D—Rotation axis of hyperboloid
- E—Geometric center of the hyperboloid's area
- H—Vertex of the paraboloid

	Angles
θ	5°00'00"
α	83°38'57"
ψ	1°21'3"
γ	13°32'47"
δ	2°9'6"
ϵ	2°50'54"
β_2	18°30'00"
β_3	19°30'28"
β_L	17°27'35"
λ	4°44'27"
η_1	14°39'31"
η_2	14°52'48"
η_E	14°48'43"

COORDINATES IN REF. TO A

	Y	X
J	107.1967	61.7663
L	122.1528	70.3839
K	0.0	65.7941

	Inches
a	178.0286
b	47.0642
c	270.0
f	229.5112
g	253.5112
h	91.6214
i	446.3239
j	196.2879
k	21.8475
l	422.8580
m	68.9118
n	333.0607
p	5.4611
q	91.9713
s	65.9990
t	112.7373
v	197.5000
u	8.0158
r_3	101.3948
r_2	127.8347

Although particular embodiments of the invention have been described and illustrated herein, it is recognized that modifications and variations may readily occur to those skilled in the art and consequently it is intended that the claims be interpreted to cover such modifications and equivalents.

What is claimed is:

1. In a Cassegrain antenna of the type including a parabolic reflector with a defined focal point and an axis of symmetry the improvement comprising:

a plurality of feed cones, each defining a phase center, said feed cones being fixedly positioned about said axis of symmetry so that the feed cones' phase centers are equidistantly positioned from said axis of symmetry in a plane perpendicular thereto; and

rotatable reflecting means for deflecting signals between a selected one of said feed cones and said parabolic reflector.

2. The Cassegrain antenna as recited in claim **1** wherein said reflecting means include an asymmetrically truncated hyperbolic reflector defining first and second conjugate foci, said first foci coinciding with the parabolic reflector focal point, said reflecting means including means for controllably relating said hyperbolic reflector about said axis of symmetry so as to bring the second focal point of said hyperbolic reflector into coincidence with the phase center of a selected one of said feed cones.

3. A Cassegrain antenna comprising:

a main parabolic reflector having a defined focal point and a defined axis of symmetry;

a plurality of feed means through which energy is transmittable, each feed means defining a phase center, said feeds means being fixedly positioned with respect

to said parabolic reflector so that their phase centers are in a plane perpendicular to said axis of symmetry;
energy reflecting means defining a first focal point and a second focal point; and
means for controllably rotating said energy reflecting means about said axis of symmetry with the first focal point of said energy reflecting means fixedly coinciding with the focal point of said parabolic reflector, and the second focal point of said energy reflecting means coinciding with the phase center of a selected one of said feed means.

4. The Cassegrain antenna as recited in claim **3** wherein said energy reflecting means comprise an asymmetric hyperbolic reflector rotatable about said axis of symmetry with the distance between its first real focal point and its second virtual focal point being equal to the distance between the focal point of said parabolic reflector and the phase center of any one of said feed means whereby when said hyperbolic reflector is focused on one of said feed means its virtual and real foci coincide with the parabolic reflector focal point and the phase center of said one feed means, respectively.

5. A Cassegrain antenna comprising:
a main reflector for focusing signals which are directed thereto substantially in parallel at a focal point thereof, said reflector defining an axis of symmetry;
a plurality of signal feeds fixedly positioned with respect to said reflector, the phase center of each feed equidistantly displayed from said axis of symmetry, with all the phase centers in a common plane perpendicular to said axis of symmetry; and
rotating subreflector means including a subreflector defining conjugate foci, and means for rotating said subreflector about said axis of symmetry, with one of the foci of said subreflector continuously coinciding with the reflector focal point until the other of the foci coincides with the phase center of a selected one of said feeds.

6. The antenna as recited in claim **5** wherein said reflector is a parabolic reflector.

7. The antenna as recited in claim **6** wherein said subreflector is an asymmetrically truncated hyperbolic subreflector.

References Cited

UNITED STATES PATENTS

3,164,835 1/1965 Alsberg ------------ 343—781

FOREIGN PATENTS

662,023 4/1963 Canada.

ELI LIEBERMAN, Primary Examiner

U.S. Cl. X.R.

343—839, 840